UNCLASSIFIED

AD NUMBER
AD838710
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; 19 JUN 1968. Other requests shall be referred to Naval Ordnance Laboratory, White Oak, MD. This document contains export-controlled technical data.**
AUTHORITY
nol ltr, 15 nov 1971

THIS PAGE IS UNCLASSIFIED

NOLTR 68-80

CAPACITOR DISCHARGE THERMAL INITIATION APPARATUS FOR HIGH ENERGY MATERIALS

19 JUNE 1968

NOL

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 68-80

CAPACITOR DISCHARGE THERMAL INITIATION APPARATUS FOR HIGH ENERGY MATERIALS

Prepared by:
Paul Kendall and
Jerome Rosen

ABSTRACT: A thermal initiation apparatus is fully described for rapidly heating and monitoring high energy materials in the range of 300 to 1000°C. Time delays to explosion, which range from 0.0[illegible] to 5 msec are a function of sample temperature. A capacitor discharge pulse heats the sample enclosed in a stainless steel hypodermic needle tubing. A constant current source is used to monitor the tubing resistance and therefore to determine its temperature. Calibration methods, sample handling techniques, and representative thermal initiation data are also reported.

PUBLISHED 19 JUNE 1968

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NOLTR 68-80 19 June 1968

Capacitor Discharge Thermal Initiation Apparatus for High Energy Materials

Studies at the Naval Ordnance Laboratory have been carried out to gain further information on the sensitivity of organic high explosive and propellant materials. A thermal sensitivity method has resulted in which small, highly confined samples are heated very rapidly to temperatures in the range of 300 to 1000°C. This report describes the design features and operation of the capacitor discharge thermal sensitivity apparatus in use at the present time. This work was performed under ORD 033 221 F008 08 11 Prob 005, Desensitization of Explosives.

E. F. SCHREITER
Captain, USN
Commander

Albert Lightbody
ALBERT LIGHTBODY
By direction

CONTENTS

ILLUSTRATIONS

TABLES

REFERENCES

(a) Wenograd, J., Trans Faraday Soc, 57, 1612 (1961)
(b) Rosen, J. M., Holden, J. R., Div of Fuel Chem, ACS, 7, 35 (1963)
(c) Kendall, P. A., "Longitudinal Vibration Induced in Metals by Thermal Shock", Applied Physics Letters, to be published May 1968

INTRODUCTION

Studies at the Naval Ordnance Laboratory have been carried out to gain further information on the sensitivity of organic high explosive and propellant materials. A thermal sensitivity method has resulted in which small, highly confined samples are heated very rapidly to temperatures in the range of 300 to 1000°C (references (a), and (b)). The time delays to explosion, which fall in the range of 50 microseconds to a few milliseconds, are measured as a function of the sample temperature. This report describes the design features and operation of the thermal sensitivity apparatus in use at the present time.

In the thermal sensitivity measurement, a 2.1 microliter sample is enclosed in a 6.35 cm length of stainless steel hypodermic needle tubing. The tubing is then heated very rapidly by discharging a capacitor through it, and its resistance is measured as a function of time. The temperature to which the tubing has been raised by the capacitor discharge is determined from the ratio of its hot resistance to its room temperature resistance. When the sample within the tube explodes, it bursts the tube wall causing an abrupt change in the resistance of the tube. Therefore, both the temperature of the sample container and the delay time before explosion are determined by measuring the resistance of the hypodermic needle tubing as a function of time. This is done by passing a constant current through the tube and monitoring the voltage across it with an oscilloscope (CRO). The delay time also is measured with an electronic timer which is started by a signal from the capacitor discharge and stopped by a signal from a microphone located near the bursting sample tube.

GENERAL CIRCUIT DESCRIPTION AND DESIGN FEATURES

The thermal initiation apparatus is shown in Figure 1 in semiblock diagram form. It consists of a series high current discharge circuit for pulse heating the explosive sample, R_0, and auxiliary circuitry and equipment to perform the required measurements and monitoring. The programmer is manually started. It then automatically controls the thermal initiation apparatus from the charging of C_0 to the exhausting of the gases from the exploded sample. In the 20 millisecond period before capacitor discharge the CRO sweep, calibrator, and constant current supply are activated sequentially in that order. The CRO horizontal sweep is triggered producing a zero voltage reference trace. The calibrator which is preset to equal the expected signal across the explosive sample switches to the -B input. The constant current unit supplies power to R_0 about one millisecond before capacitor discharge and remains in that state for about 20 milliseconds. At capacitor discharge the CRO sweep is again triggered. The signal across the sample minus the calibrator voltage (A-B) provide essentially null operation. This makes it possible to operate the CRO at a high vertical sensitivity, usually about 20 mv/cm. The resistance at ambient temperature, R_0, is measured prior to automatic operation. This is done by using a very low steady state constant current and monitoring the voltage across R_0 with a L&N potentiometer. The condition of low current and the 20 millisecond powering time during automatic operation is required in each case to avoid resistance change problems due to heating.

The component values listed for the discharge circuit shown in Figure 1 were chosen for a slightly underdamped condition. This insured a positive cutoff for the 5C22 and, therefore, a clean negative current pulse through R_0. A maximum capacitor voltage of about 3000 volts ($\simeq$1600 ampere discharge) is required to increase R_0 from 0.6Ω at room temperature to 1Ω which corresponds to about 1000°C. The discharge period lasts about 20 μsec. The constant current supply consists of a series resistance, a fast acting mercury relay and a solid state 54 volt power supply. The series resistance consists of two 25Ω parallel resistors for automatic operation and switches to a 1000Ω component for initial R_0 measurement. The solid state power supply is protected from the high voltage discharge pulse by a 16,000 μF capacitor bank. The capacitor bank, non-inductive resistors, and a fast acting mercury relay are located very close to R_0. This is done to minimize the inductance of the interconnecting wires since the inductance of the constant current unit adversely affects the recovery time of the system from the high voltage pulse. The CRO is safisfactorily isolated from the high negative voltage pulse by the simple diode clipping circuit shown in Figure 1. It clips the high negative voltage pulse and passes, essentially unattenuated, the positive dc signal. This clipping diode has a relatively slow response but was chosen because it has no overshoot. However, this diode is adequate for studies down to 50 μsec. In addition for reliable operation all connections were soldered in the high current discharge circuit with the exception of the two screw clamps used to hold the sample explosive. This was particularly important for those connections exposed to the corrosive gases of the exploding samples. The stainless steel tube holding the explosive sample was soldered to two small brass posts that in turn were securely held by the two screw clamps.

An exploding wire record is shown in Figure 2 from which the delay time to explosion, and indirectly temperature measurements are obtained. It should also be noted that the trace oscillation seen in the figure is a mechanical longitudinal motion of the stainless steel sample tube (reference (c)). We assume that the oscillations result from the rapid bulk expansion of the metal due to heating and because of its elastic nature reacts as a mechanical oscillator.

CALIBRATION

A resistivity-temperature* curve of the hypodermic needle tubing was determined by measuring the resistance at several different

*Resistivity is here defined as the ratio of the hot resistance, R_1, to the room temperature resistance, R_0.

temperatures, Figure 3. Fifty centimeter sections of the tubing were heated in a well insulated muffle furnace. At equilibrium, the resistances were measured along with that of a platinum resistance thermometer. Above 754°C we were not able to achieve equilibrium conditions probably because of both oxidation and slow annealing of the tubing. Each point represents the average from measurements made on three sections of tubing. The extrapolated part of our curve was in good agreement with previous data obtained with an optical pyrometer (reference (a)).

Several calibration resistors were made from #20 manganin wire to cover, adequately, the complete range of resistance found for heated sample tubes--about 0.6 to 1.0 ohm. Their resistance values were measured accurately on a Kelvin bridge and rechecked from time to time. The null voltage of each resistor was measured in the circuit in the automatic mode with the exception of capacitor discharge to obtain a voltage-resistance calibration curve. This relationship was then used to determine the resistance of the heated sample tube, R_1, from the monitored voltage on the oscillogram.

For convenience, temperature is computed by an IBM 7090 digital computer using a program written for that purpose. However, it may be obtained from the temperature-resistivity calibration after first obtaining the resistivity from measured values of R_0 and R_1.

SAMPLE HANDLING

The sample tubes are filled with a liquid by placing the open ends in the liquid as shown, Figure 4. The other ends are closed by spot welding. Air is removed from the tubing by a vacuum pump. When the atmosphere is readmitted, the liquid is forced into the tubing.

Essentially the same system is used for solids except that solids must be heated above the melting point. A silicone liquid bath is used. Thermal sensitivity measurements cannot be made on materials which decompose rapidly in the liquid state.

REPRESENTATIVE DATA

Typical data plots of the logarithm of the delay time to explosion as a function of the reciprocal of the absolute temperature are shown in Figure 5 for three representative liquids. In addition to computing temperatures, the program yields a least square fit of the data to the straight line defined by

$$\log_{10} \text{ delay time in milliseconds} = A + \frac{1000\ B}{T, °K} .$$

One way to compare thermal sensitivities is to examine the temperatures required for initiation at a given time delay. These are listed in Table I for a heating period of 250 microseconds, a convenient point of reference. If a thermal pulse of 422°C is generated for 250 microseconds we should expect triethylene glycol dinitrate to be initiated. These same conditions of time and temperature would not have a significant effect on nitromethane and n-propyl nitrate. As triethylene glycol dinitrate is the easiest to initiate, we conclude it is the most sensitive under the conditions described.

Sensitivity ranking by the Wenograd thermal initiation method are generally in good agreement with ranking by other sensitivity methods generating thermal pulses in the range of 0.1 to 1 millisecond.

ACKNOWLEDGMENT

The computer program was written by J. R. Holden and C. Dickinson. We are grateful for the assistance of Eleanore Kayser and Patrick Barry.

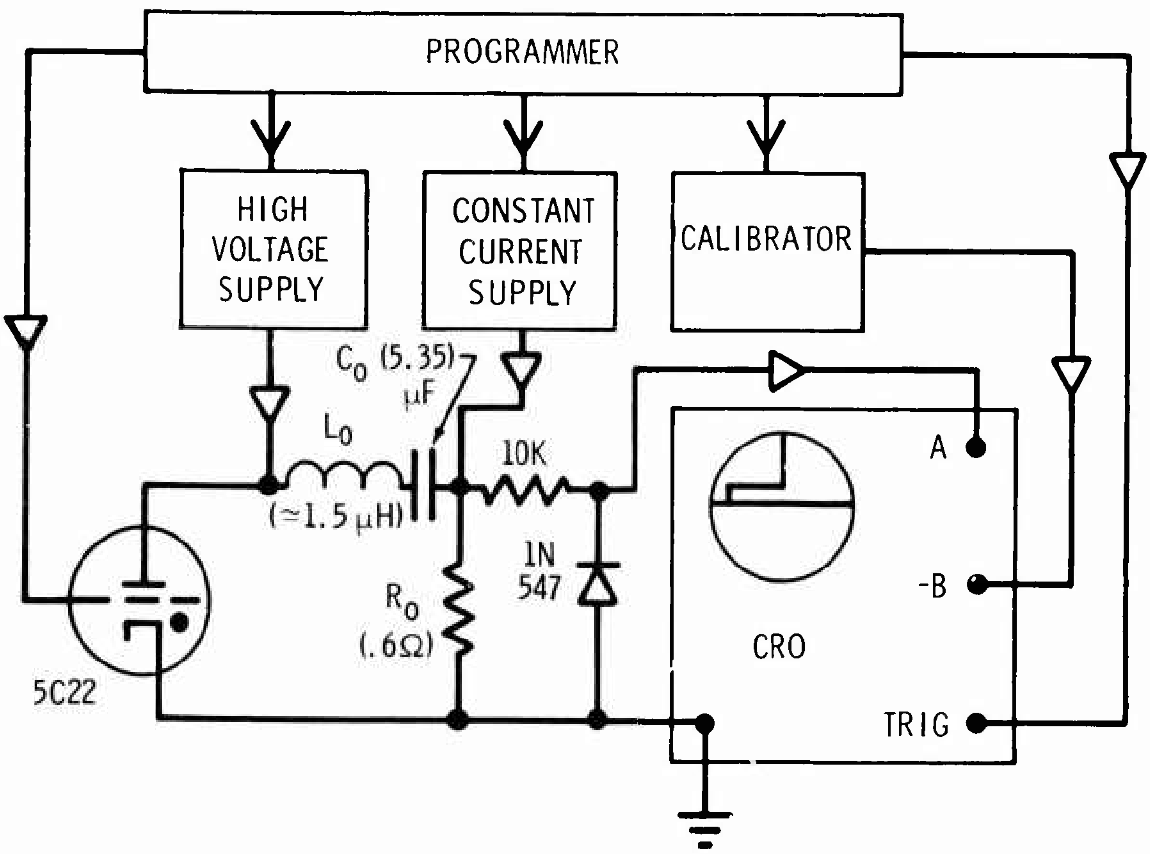
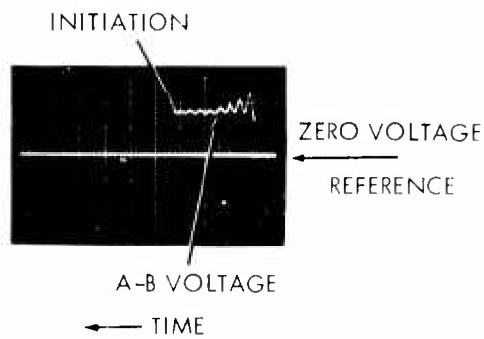


FIG. 1 THERMAL INITIATION APPARATUS



SWEEP SPEED = 50 μ SEC/CM
VERTICAL SENSITIVITY = 20 MV/CM
CAPACITOR DISCHARGE = 2250 V

FIG. 2 OSCILLOGRAM RECORD OF INITIATION

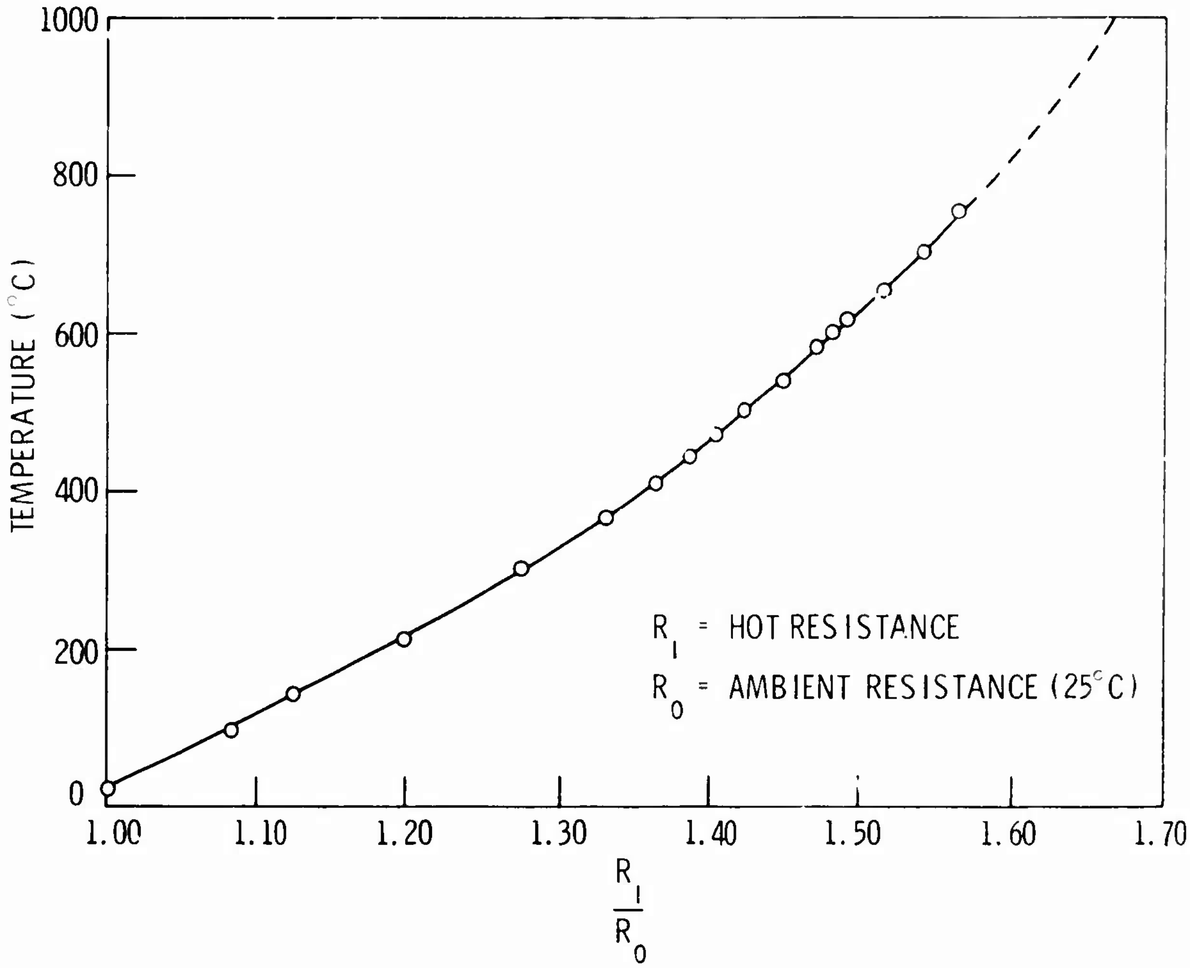


FIG. 3 TEMPERATURE-RESISTIVITY CALIBRATION
#28 STAINLESS STEEL HYPODERMIC NEEDLE TUBING

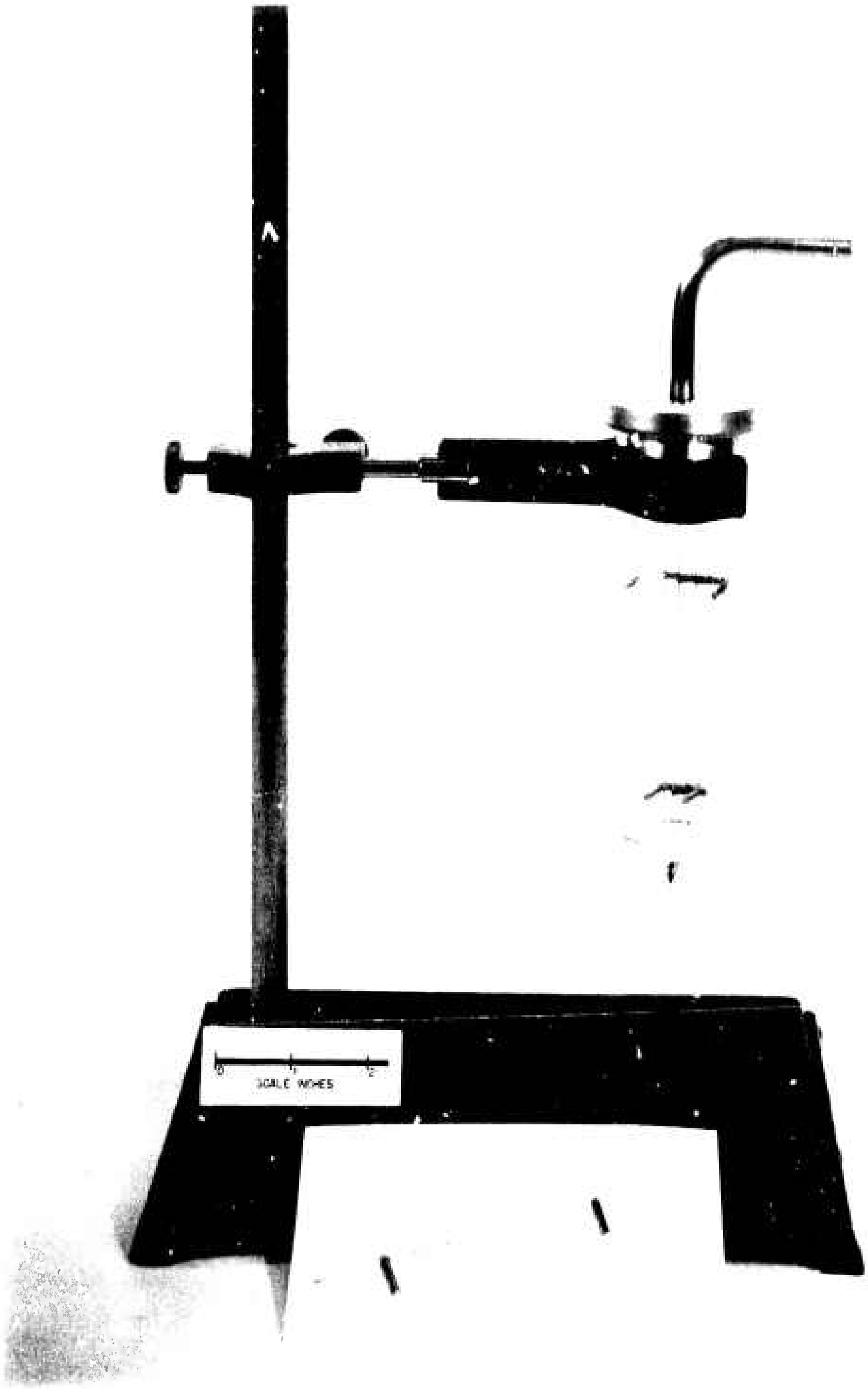
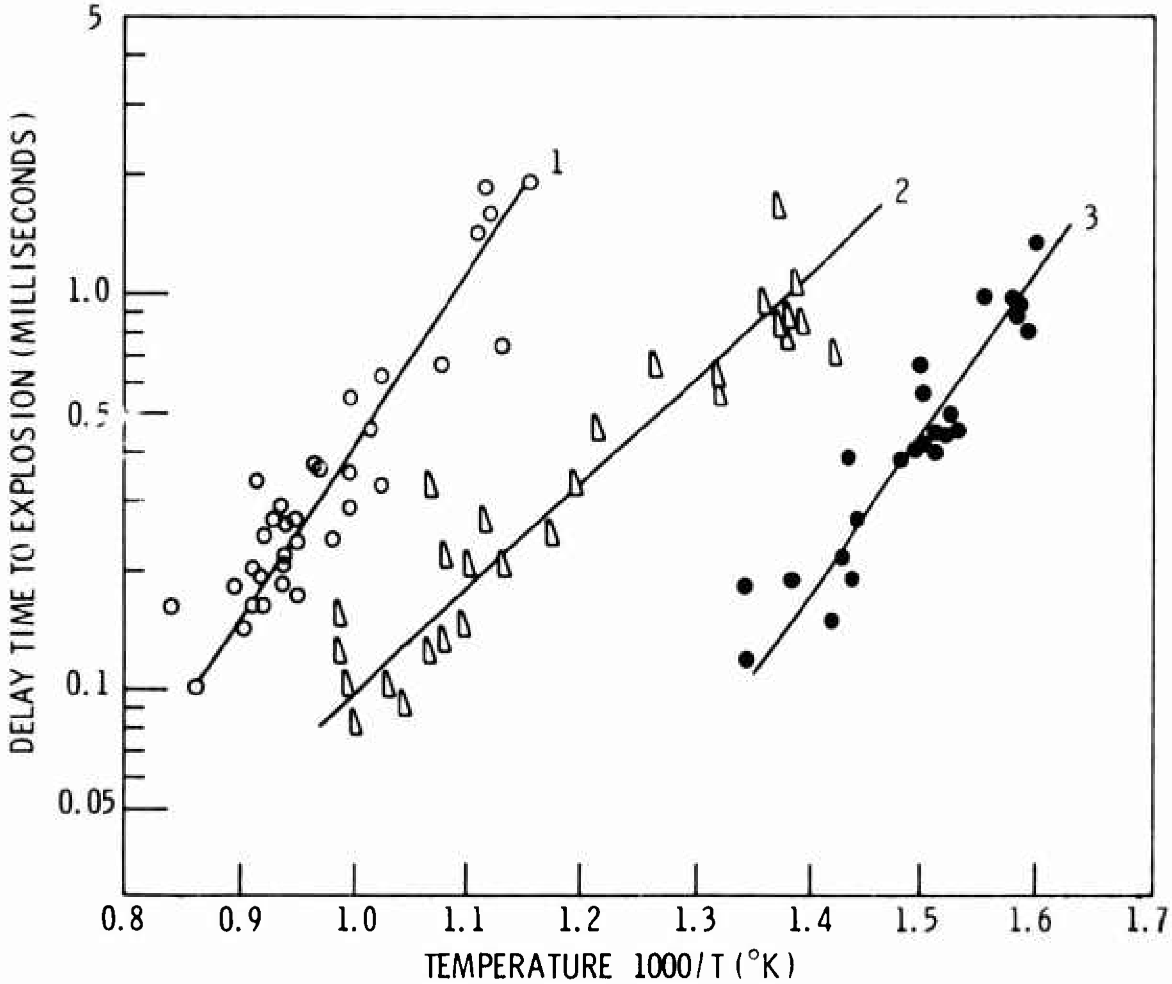


FIG. 4 SAMPLE LOADING TUBE



1. NITROMETHANE
2. n-PROPYL NITRATE
3. TRIETHYLENE GLYCOL DINITRATE

FIG. 5 THERMAL INITIATION DATA

TABLE I

THERMAL INITIATION TEMPERATURE
250 MICROSECOND HEATING TIME

Compound	Temperature, °C
Nitromethane	780
n-Propyl Nitrate	593
Triethylene Glycol Dinitrate	422

APPENDIX A

DETAILED CIRCUIT OPERATION

This detailed description is included as a construction or maintenance guide for the thermal initiation apparatus. Refer to the fold-out circuit diagram Figure A-6 and Table A-II for the following discussion.

The apparatus is ac powered by switches S1, S2, and a front panel switch on power supply PS3. There is a four minute delay for heating the thyratron (5C22) filament after which time the pilot light P2, indicates ac power is available for the high voltage power supply PS1. Before activating PS3 its current control is adjusted for about 1A so that the 16,000 μF bank will not impose an excessive load on PS3. After charging the 16,000 uF bank the current control is set at maximum level.

The charge push button switch S3 can now be depressed to bring the ac power to PS1, the "delay timer", the variac T2, and the self locking relay Re6. Relay Re6 immediately by-passes S3 thus effectively taking it out of the circuit. (Note switch S9 in the firing chamber must be closed for Re6 to operate.) The variac T1 is set for the desired high voltage ranging from 300 to 3000 volts, and the "delay relay" is set for 25 seconds changing time.

At the end of this changing period the "delay timer" switches state, turning off the high voltage power supply and turning on the exhaust fan in the "firing chamber". With the switch S4 in the "on" or "auto-fire" position the "delay timer" also automatically controls the voltage calibration, the powering of R_O in the "firing chamber", and the firing of the thyratron. Otherwise with the S4 open, S5 can be used to manually activate these sub-units.

The switching of the "delay timer" or S5 controls the triggering of the SCR (2N 1881) and energizes relay Re1. The output from the SCR triggers the CRO horizontal sweep for a zero volts reference trace. Re1 switches about 20 msec after the switching of the "delay timer". Re1 controls the energizing of Re2, Re3, and Re4. Re2 switches first, applying a calibration voltage to the -B input of the CRO vertical amplifier. Re4 switches about 1 msec later connecting PS3 to R_O via the two 25Ω parallel isolating resistors in the "firing chamber". Re3 switches about 1 msec later connecting the 1 μF capacitor that is charged to the voltage of PS2 to the pulse transformer T6 for firing the thyratron. Re1 returns to its original state about 20 msec after initially switching, thus returning relays Re2, Re3, and Re4 to their original open state. Note this means R_O is powered by PS3 about 20 msec. Concurrently with the firing of the thyratron (5C22) for discharging the high voltage energy storage capacitor a capacitor divider from the energy storage capacitor provides a low voltage pulse for triggering the horizontal CRO sweep and the counter interval timer. The CRO and camera display and record the signal across R_0. The crystal microphone located next to R_0 picks up the detonation bang thus stopping the interval timer.

When the "firing chamber" cover is raised, three microswitches S7, S8, and S9 are opened, and ac power is removed from 3 relays, Re5, 9, and 6 respectively. For safety Re5 shorts out the energy storage capacitor. To measure the voltage drop across R_0 and thus determine its resistance Re9 connects both a low constant current circuit ($\simeq$50 ma) to the sample explosive resistor R_0, and a L&N potentiometer. The self locking relay Re6 is also reset, and thus ac power is removed from the "delay timer", the variac T1, and the exhaust fan. All relays have now been returned to their original state, and with the closing of the firing chamber the unit is ready for another test firing.

TABLE A-II

COMPONENT FUNCTION AND DESCRIPTION

Relays

	Function	Description
Re1	Delay	New Products, Inc - reed relay #162 coil - 6V at 700 ohms
Re2	Auto-Cal	Stevens Arnold, Inc - millisec relay coil - 18V at 1400 ohms
Re3	Thyratron Fire	C. P. Clare & Co - mercury relay type HQP-1002 coil - 12V at 4500 ohms
Re4	R_0 Power	Same as Re3
Re5	Safety (Capacitor Discharge)	Struthers Dunn Co - power relay type 8BXX - coil 115V AC
Re6	Latching Relay for Capacitor Charge	Advance Electric & Relay Co type A-2041419 coil 115V AC
Re7, 8	Preheat Thyratron Filament 4 Minutes	Amperite - 6V N/O 120 sec
Re9	Resistance Measurement	Same as Re6 and with hermetic sealing

Switches

S1	AC Power	SPST
S2	AC Power	DPDT
S3	Capacitor Charge	Pushbutton N/O
S4	Automatic Fire	SPST
S5	Manual Fire	Pushbutton N/O
S6	Static Calibration	SPST

Switches (Continued)

	Function	Description
S7	De-energize Re5 to Discharge Capacitor When Firing Chamber Open or Power Failure	Microswitch SPST N/O
S8	De-energize Re7 for Resistance Measurement When Firing Chamber Open	Microswitch SPST N/O
S9	Reset Re6 When Firing Chamber is Opened	Microswitch N/O

Timer

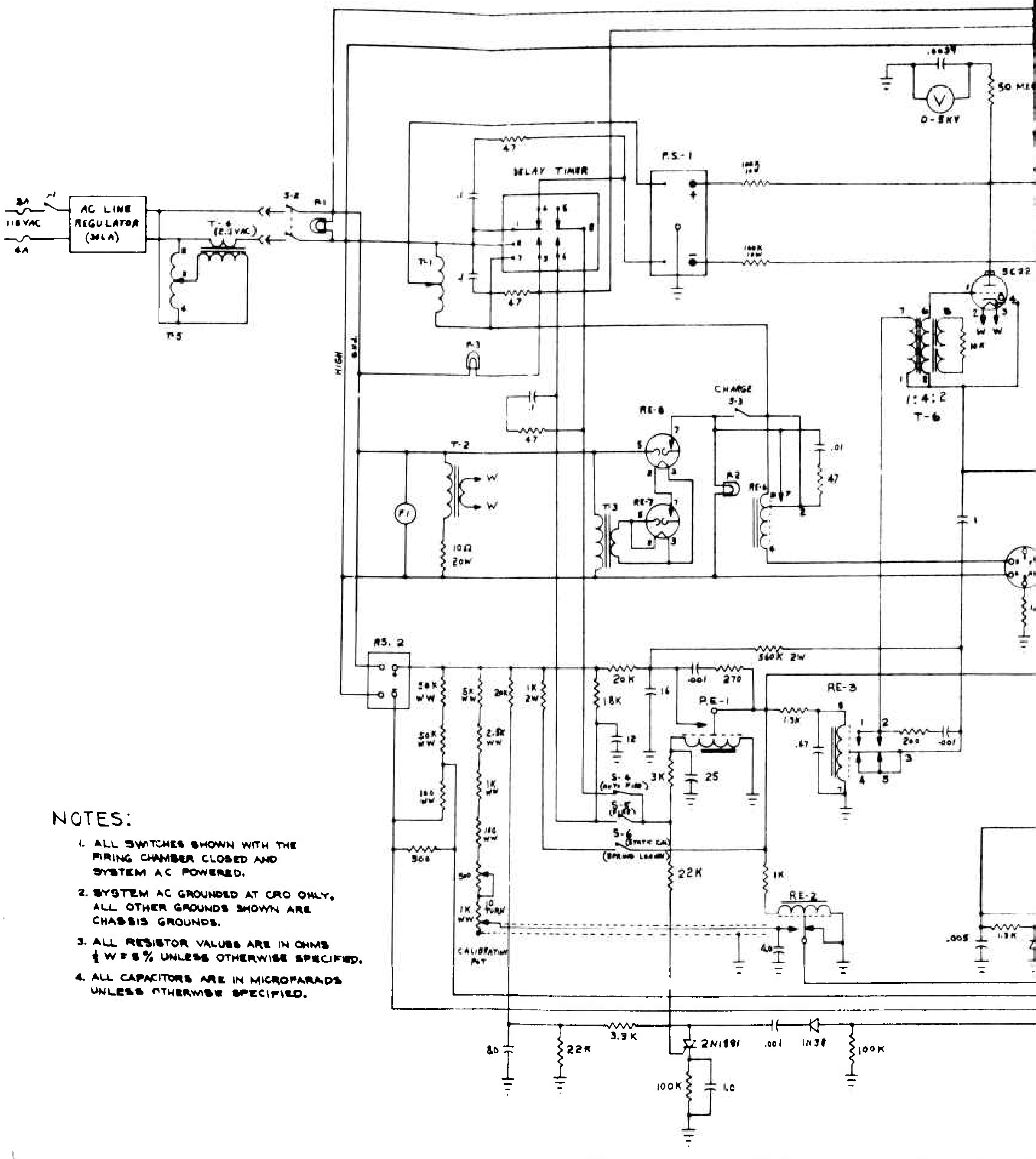
Delay Timer	Control Capacitor Charging Time, etc	Syracuse Electronics Corp TR-302 DPDT-5A-N/O

Power Supplies

PS#1	Universal Voltronics Corp BPE-10-5.5 (0-10KV at 5.5 ma)
PS#2	Sorensen Model QM/48V at 40 ma
PS#3	NJE Corp Model SY-60-6-M (10-60V @ 6 amp)

Transformers

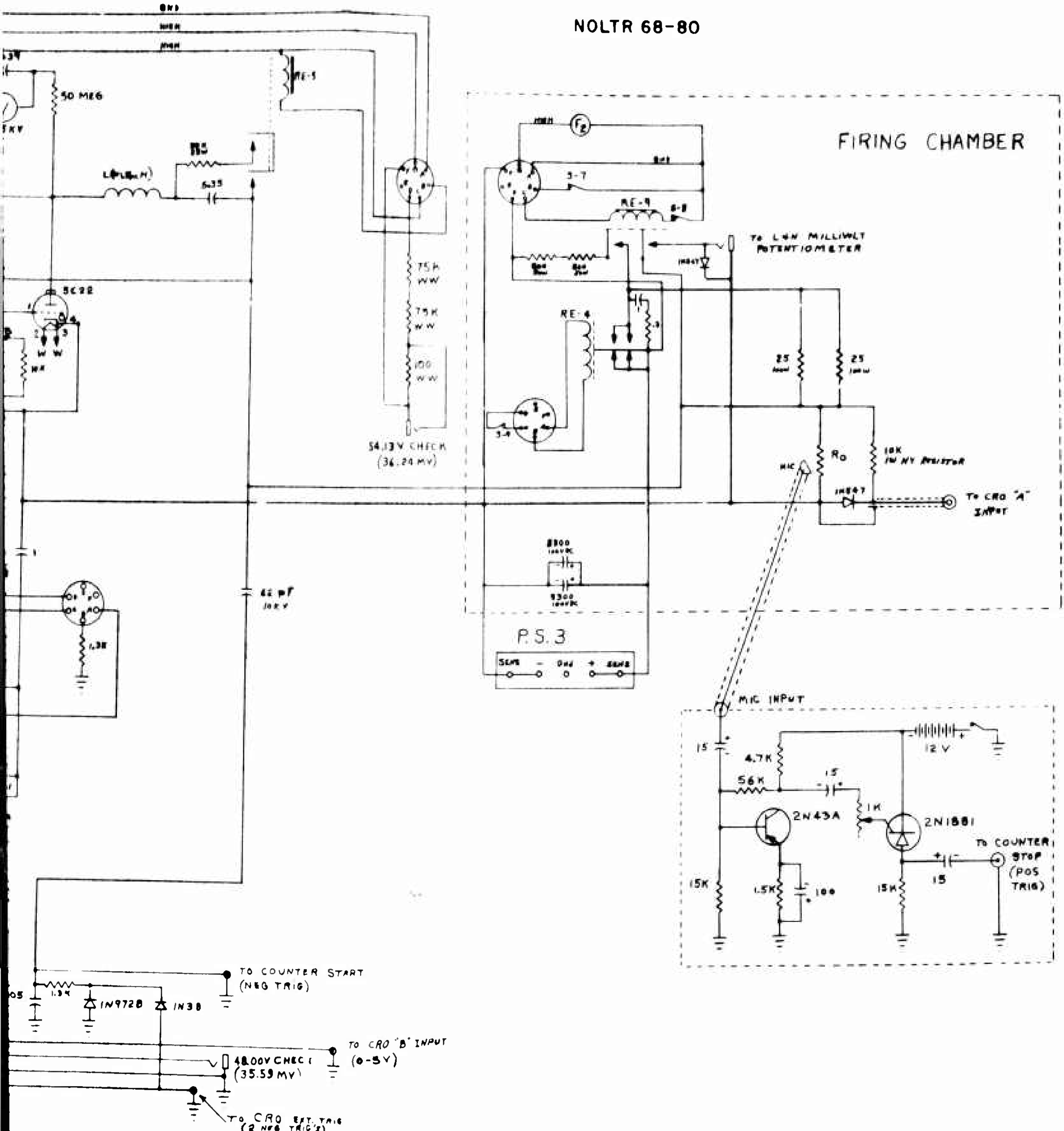
T1	High Voltage Control	GR Variac at 1 amp
T2	Filament	Stancor P6308 - 6.3 V AC at 10 amp
T3	Thermal Delay Power	6.3 V AC at 1.2 amp
T4	Fine AC Control for Incremental Changes	2.5V AC at 3 amp
T5	of PS#1	GR Variac at 1 amp
T6	Trigger Thyratron	Pulse Engineering #2982



NOTES:

1. ALL SWITCHES SHOWN WITH THE FIRING CHAMBER CLOSED AND SYSTEM AC POWERED.
2. SYSTEM AC GROUNDED AT CRO ONLY. ALL OTHER GROUNDS SHOWN ARE CHASSIS GROUNDS.
3. ALL RESISTOR VALUES ARE IN OHMS ¼ W ± 5% UNLESS OTHERWISE SPECIFIED.
4. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

FIGURE A-6 THERMAL INITIATION APPARATUS


FIRING CHAMBER
50 MEG
5C22
RE-4
RE-5
75K WW
75K WW
100 WW
54.13 V CHECK (36.24 MV)
TO L&N MILLIVOLT POTENTIOMETER
25
25
Ro
10K
1N47
TO CRO "A" INPUT
MIC
P.S. 3
SENS - GND + SENS
42 pF 10KV
MIC INPUT
12 V
4.7K
56K
15
1K
2N43A
2N1881
TO COUNTER STOP (POS TRIG)
15K
1.5K
100
15K
TO COUNTER START (NEG TRIG)
1N972B
1N38
TO CRO "B" INPUT (0-5V)
4800V CHECK (35.59 MV)
TO CRO EXT. TRIG (2 NEG TRIG'S)

RATUS

DISTRIBUTION

	No. of Copies
Commander U. S. Naval Ordnance Systems Command Washington, D. C. 20360	
ORD-913	2
ORD-034	1
ORD-035	1
ORD-033	1
ORD-0332	1
ORD-031	1
AIR-330B	1
Chief Office of Naval Research Washington, D. C. 20360	
Power Branch, Code 429	1
Technical Library	1
Commanding General Army Materiel Command Washington, D. C. 20315	
ARCRD	1
Technical Library	1
Director Naval Research Laboratory Washington, D. C. 20390	
Chemistry Division	1
Technical Library	1
Director Los Alamos Scientific Laboratory P. O. Box 1663 Los Alamos, New Mexico 87544	
Dr. L. C. Smith	1
Dr. Howard Cady	1
Technical Library	1
Director Lawrence Radiation Laboratory University of California, Box 808 Livermore, California 94550	
Dr. Gus Dorough	1
Dr. John Kury	1

	No. of Copies
Naval Postgraduate School Monterey, California 93940 Dr. Carl Hering	2
Dr. James E. Sinclair	1
Commander Hill Air Force Base, Utah 84401 OOAMA	1
Director Chemical Propulsion Information Agency The Johns Hopkins University 8621 Georgia Avenue Silver Spring, Maryland 20910 Technical Library	1
Director Defense Documentation Center Cameron Station Alexandria, Virginia 22314 TIPCR	20
Director Special Projects Office Department of the Navy Washington, D. C. 20360 Technical Library	1
Commanding Officer Naval Weapons Station Yorktown, Virginia 23491	1
Commander Naval Weapons Center, Corona Laboratories Corona, California 91720 Technical Library	1
Commander Naval Weapons Center China Lake, California 93557 Chemistry Research Section	1
Commander Eglin Air Force Base, Florida 32542 Det. 4, ASD, Weapons Division, ASQWR	1
Commanding Officer Naval Ammunition Depot Crane, Indiana	1

	No. of Copies
Harry Diamond Laboratories Connecticut Ave. & Van Ness St., N. W. Washington, D. C. 20438	
Milton Lipnick	1
Commanding Officer U. S. Naval Ordnance Station Indian Head, Maryland 20640	
Research & Development Department	1
Technical Library	1
Commanding General Aberdeen Proving Ground Aberdeen, Maryland 21055	
Ballistics Research Center	1
Commanding Officer U. S. Army Ordnance Missile Command Redstone Arsenal Huntsville, Alabama 35809	
Barry Allan	1
J. W. Connoughton	1
Commanding Officer Picatinny Arsenal Dover, New Jersey 07801	
Chemistry Research Section	1
U. S. Naval Ammunition Depot Navy No. 66 c/o Fleet Post Post Office San Francisco, California 96612	
Quality Evaluation Laboratory	1
Aerojet-General Corporation P. O. Box 296 Azusa, California 91703	
J. R. Fischer	1
Aerojet-General Corporation 1711 South Woodruff Avenue Downey, California 90241	
W. E. Voreck	1
Aerojet-General Corporation P. O. Box 1947 Sacramento, California 95809	
Dr. Marvin Gold	1

	No. of Copies
Explosive Technology, Inc. Box KK, Fairfield, California 94533 Mr. F. Burkdoll	1
National Aeronautics & Space Administration Manned Spacecraft Center P. O. Box 1537 Houston, Texas 77058 Mr. T. J. Graves	1
Library	1
North American Aviation, Inc. Space & Information Systems Division 12214 Lakewood Boulevard Downey, California 90242	1
Department of Interior Bureau of Mines Bruceton, Pennsylvania 15213 Dr. C. M. Mason	1
NASA, George C. Marshall Spaceflight Center Huntsville, Alabama 35812 Library	1
R. White, R-P and VE-PMS	1
NASA, Lewis Research Center 21000 Brookpark Road Cleveland, Ohio 44135 Library	1
Michael Pavlick, Centaur, 4-9	1
Roger Palmer, Agena, 4-8	1
Paul Ordin, SNPO	1
Sandia Corp. P. O. Box 5400 Albuquerque, New Mexico 87115 Mr. W. J. Meikle	1
Sandia Corp. P. O. Box 969 Livermore, California 94550	1
Central Technology, Inc. Box 231 Herrin, Illinois 62948 S. M. Carter	1

	No. of Copies
Ames Research Center Moffett Air Force Base, California 94035 Librarian	2
AVCO Corporation 201 Lowell Stret Wilmington, Massachusetts 01887 H. Weintraub	1
Ensign-Bickford Co. 660 Hopmeadow Street Simsbury, Connecticut 06070 Mr. T. Norton	1
Mr. W. Smith	1
General Dynamics Fort Worth, Texas 76101 Joe White, Jr., T-104	1
William Early, Jr., K-49	1
General Electric Co. 2198 Chestnut Street Philadelphia, Pennsylvania 19103 Re-entry Systems Department	1
Link Ordnance Division, General Precision 670 Arques Avenue Sunnyvale, California 94086 D. E. Davenport	1
McDonnell Douglas P. O. Box 516 St. Louis, Missouri 63166 Morry Schimmel, Dept. 331	3
Harry Lutz	1
Victor W. Drexelius	1
Scientific & Technical Information Facility, NASA P. O. Box 33 College Park, Maryland 20740	1
Space Ordnance Systems, Inc. 133 Penn Street El Segundo, California W. F. Bell	1
Northrop Carolina Box 3049 Asheville, N. C. 28802 G. T. White	1

	No. of Copies
Lockheed Missiles & Space Co. Dept 52-30, Bldg. 204 3251 Hanover Street Palo Alto, California 94304 Dr. Richard A. Glass	1
Holston Defense Corporation Building 8, Area B Kingsport, Tennessee 37660 Paul L. Lee	1
The Franklin Institute 20th & Benjamin Franklin Parkway Philadelphia, Pennsylvania 19130 Technical Library	2
Thiokol Chemical Corporation P. O. Box 27 Bristol, Pennsylvania 19007 R. Morris	1
Unidynamics P. O. Box 2990 Phoenix, Arizona 85002 R. D. Smith	1
Rohm & Haas Company Redstone Arsenal Research Division Huntsville, Alabama 35808 Dr. T. H. Pratt	1
Space Technology Laboratory, Inc. Redondo Beach, California 90200 Technical Library	1
Dr. E. A. Burns	1
Southwest Research Institute 8500 Calebra Road San Antonio, Texas 78206 W. R. Blackstone	1
Esso Research and Engineering Co. P. O. Box 8 Linden, New Jersey 07036 Dr. John Brown	1
Rocketdyne 6633 Canoga Avenue Canoga Park, California 91304 Dr. J. Sinor	1

	No. of Copies
LTV Aerospace Corporation P. O. Box 6267 Dallas, Texas 75222 Ural M. Robinson	1
Hercules, Inc. Alleghany Ballistics Lab P. O. Box 210 Cumberland, Maryland 21501 Mr. Donal Smith	1
Midwest Research Institute 425 Volker Boulevard Kansas City, Missouri 64110 Dr. Ivan C. Smith	1
Astropower Laboratory McDonnell Douglas Corp. 2121 Campus Drive Newport Beach, California 92667 Dr. W. David English	1

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) U. S. Naval Ordnance Laboratory White Oak Silver Spring, Maryland	2a REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b GROUP

3 REPORT TITLE

Capacitor Discharge Thermal Initiation Apparatus for High Energy Materials

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

5 AUTHOR(S) (Last name, first name, initial)

Kendall, Paul A.
Rosen, Jerome M.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
19 June 1968	15	4

8a CONTRACT OR GRANT NO b PROJECT NO ORD 033 221 F008 08 11 Prob 005 c d	9a ORIGINATOR'S REPORT NUMBER(S) NOLTR 68-80 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10 AVAILABILITY/LIMITATION NOTICES

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY

13 ABSTRACT

A thermal initiation apparatus is fully described for rapidly heating and monitoring high energy materials in the range of 300 to 1000°C. Time delays to explosion, which range from 0.05 to 5 msec are a function of sample temperature. A capacitor discharge pulse heats a sample enclosed in a hypodermic needle tubing. Calibration methods, sample handling techniques, and representative data are also reported.

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Capacitor Discharge Thermal Initiation Explosives						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

UNCLASSIFIED

Security Classification

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 68-80).
CAPACITOR DISCHARGE THERMAL INITIATION APPARATUS FOR HIGH ENERGY MATERIALS, by Paul Kendall and Jerome Rosen. 19 June 1968. 10p. illus., charts, tables. NOSC task ORD 033 221 F008 08 11.

UNCLASSIFIED

A thermal initiation apparatus is fully described for rapidly heating and monitoring high energy materials in the range of 300 to 1000°C. Time delays to explosion, which range from 0.05 to 5 msec are a function of sample temperature. A capacitor discharge pulse heats a sample enclosed in a hypodermic needle tubing. Calibration methods, sample handling techniques, and representative data are also reported.

1. Capacitors - Discharge
2. Explosives - Initiation
3. Explosives, High energy
I. Title
II. Kendall, Paul A.
III. Rosen, Jerome A., jt. author
IV. Project

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 68-80).
CAPACITOR DISCHARGE THERMAL INITIATION APPARATUS FOR HIGH ENERGY MATERIALS, by Paul Kendall and Jerome Rosen. 19 June 1968. 10p. illus., charts, tables. NOSC task ORD 033 221 F008 08 11.

UNCLASSIFIED

A thermal initiation apparatus is fully described for rapidly heating and monitoring high energy materials in the range of 300 to 1000°C. Time delays to explosion, which range from 0.05 to 5 msec are a function of sample temperature. A capacitor discharge pulse heats a sample enclosed in a hypodermic needle tubing. Calibration methods, sample handling techniques, and representative data are also reported.

1. Capacitors - Discharge
2. Explosives - Initiation
3. Explosives, High energy
I. Title
II. Kendall, Paul A.
III. Rosen, Jerome A., jt. author
IV. Project

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 68-80).
CAPACITOR DISCHARGE THERMAL INITIATION APPARATUS FOR HIGH ENERGY MATERIALS, by Paul Kendall and Jerome Rosen. 19 June 1968. 10p. illus., charts, tables. NOSC task ORD 033 221 F008 08 11.

UNCLASSIFIED

A thermal initiation apparatus is fully described for rapidly heating and monitoring high energy materials in the range of 300 to 1000°C. Time delays to explosion, which range from 0.05 to 5 msec are a function of sample temperature. A capacitor discharge pulse heats a sample enclosed in a hypodermic needle tubing. Calibration methods, sample handling techniques, and representative data are also reported.

1. Capacitors - Discharge
2. Explosives - Initiation
3. Explosives, High energy
I. Title
II. Kendall, Paul A.
III. Rosen, Jerome A., jt. author
IV. Project

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 68-80).
CAPACITOR DISCHARGE THERMAL INITIATION APPARATUS FOR HIGH ENERGY MATERIALS, by Paul Kendall and Jerome Rosen. 19 June 1968. 10p. illus., charts, tables. NOSC task ORD 033 221 F008 08 11.

UNCLASSIFIED

A thermal initiation apparatus is fully described for rapidly heating and monitoring high energy materials in the range of 300 to 1000°C. Time delays to explosion, which range from 0.05 to 5 msec are a function of sample temperature. A capacitor discharge pulse heats a sample enclosed in a hypodermic needle tubing. Calibration methods, sample handling techniques, and representative data are also reported.

1. Capacitors - Discharge
2. Explosives - Initiation
3. Explosives, High energy
I. Title
II. Kendall, Paul A.
III. Rosen, Jerome A., jt. author
IV. Project